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(54) Cleaning processes and compositions

(57) A method for cleaning an article comprises contacting the article with a cleaning composition comprising a linear or branched volatile siloxane.

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valent alkyl radicals, monovalent aryl radicals and monovalent aralkyl radicals.

[0014] As used herein, the term "(C_1-C_6)alkyl" means a linear or branched alkyl group containing from 1 to 6 carbons per group, such as, for example, methyl, ethyl, propyl, iso-propyl, n-butyl, iso-butyl, sec-butyl, tert-butyl, pentyl, hexyl, preferably methyl.

[0015] As used herein, the term "aryl" means a monovalent unsaturated hydrocarbon ring system containing one or more aromatic rings per group, which may optionally be substituted on the one or more aromatic rings, preferably with one or more (C_1-C_6)alkyl groups and which, in the case of two or more rings, may be fused rings, including, for example, phenyl, 2,4,6-trimethylphenyl, 2-isopropylmethylphenyl, 1-pentalenyl, naphthyl, anthryl, preferably phenyl.

[0016] As used herein, the term "aralkyl" means an aryl derivative of an alkyl group, preferably a (C_2-C_6)alkyl group, wherein the alkyl portion of the aryl derivative may, optionally, be interrupted by an oxygen atom, such as, for example, phenylethyl, phenylpropyl, 2-(1-naphthyl)ethyl, preferably phenylpropyl, phenyoxypropyl, biphenyloxypropyl.

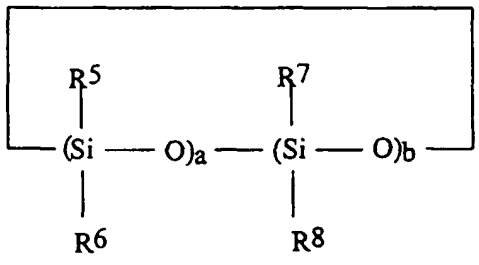
[0017] In a preferred embodiment, the monovalent hydrocarbon radical is a monovalent (C_1-C_6)alkyl radical, most preferably, methyl.

[0018] In a preferred embodiment, the linear or branched, volatile siloxane comprises one or more of, hexamethyldisiloxane, octamethyltrisiloxane, decamethyltetrasiloxane, dodecamethylpentasiloxane, tetradecamethylhexasiloxane or hexadecamethylheptasiloxane or methyltris(trimethylsiloxy)-silane. In a more highly preferred embodiment, the linear or branched, volatile siloxane of the present invention comprises octamethyltrisiloxane, decamethyltetrasiloxane, or dodecamethylpentasiloxane or methyltris-(trimethylsiloxy)silane. In a highly preferred embodiment, the siloxane component of the composition of the present invention consists essentially of decamethyltetrasiloxane.

[0019] Suitable linear or branched volatile siloxanes are made by known methods, such as, for example, hydrolysis and condensation of one or more of tetrachlorosilane, methyltrichlorosilane, dimethyldichlorosilane, trimethylchlorosilane, or by isolation of the desired fraction of an equilibrate mixture of hexamethyldisiloxane and octamethylcyclotetrasiloxane or the like and are commercially available.

[0020] Compounds suitable as the cyclic siloxane component of the present invention are those containing a polysiloxane ring structure that includes from 2 to 20 silicon atoms in the ring. Preferably, the linear, volatile siloxanes and cyclic siloxanes are relatively volatile materials, having, for example, a boiling point of below about 300°C at a pressure of 760 millimeters of mercury ("mm Hg").

[0021] In a preferred embodiment, the cyclic siloxane component comprises one or more compounds of the structural formula (II):



(II)

wherein:

R^5, R^6, R^7 and R^8 are each independently a monovalent hydrocarbon group; and

a and b are each integers wherein $0 \le a \le 10$ and $0 \le b \le 10$, provided that $3 \le (a + b) \le 10$.

[0022] In a preferred embodiment, the cyclic siloxane comprises one or more of, octamethylcyclotetrasiloxane, decamethylcyclopentasiloxane, dodecamethylcyclohexasiloxane, tetradecamethylcycloheptasiloxane. In a more highly preferred embodiment, the cyclic siloxane of the present invention comprises octamethylcyclotetrasiloxane or decamethylcyclopentasiloxane. In a highly preferred embodiment, the cyclic siloxane component of the composition of the present invention consists essentially of decamethylcyclopentasiloxane.

[0023] Suitable cyclic siloxanes are made by known methods, such as, for example, hydrolysis and condensation of dimethyldichlorosilane and are commercially available.

[0024] It is believed that those cleaning compositions according to the present invention that lack a cyclic siloxane component would be more stable than those which include a cyclic siloxane component, in that cyclic siloxanes are

application of heat, preferably, heating to a temperature of from 15 °C to 120 °C, preferably from 20 °C to 100 °C, or reduced pressure, preferably, a pressure of from 1 mm Hg to 750 mm Hg, or by application of heat and reduced pressure, to the article.

[0033] The cleaning method of the present invention removes particulate soils, such as for example, insoluble particles such as silicates, carbon black, as well as both polar stains, such as for example, salts, sugars, water soluble biological fluids, and nonpolar stains, such as, for example, hydrocarbons, oils, greases, sebum, from the garment and prevents the redeposition of the soils, polar stains and nonpolar stains on the article.

EXAMPLES 1-162

[0034] The respective cleaning compositions used in Examples 1-162 were each prepared by combining the components listed below in the relative amounts set forth below in TABLES I - XIV below:

methyl terminated tetradimethyl siloxane ("MD_2M");

decamethylcyclopentasiloxane ("D_5");

polyether siloxane compounds, each according to structural formula III above, were used:

Polyether siloxane	e	f	g	Ratio C_2H_4O C_3H_6O	Number average molecular weight (MW_n)of polyether substituent	R^{13}
A	2	20	3	50: 50	1700	H
B	2	15	5	100: 0	550	H
C	0	3	0	100: 0	900	H
D	0	3	0	100: 0	200	H
E	2	500	6.5	50: 50	1700	H
F	2	400	18	100: 0	550	H

[0035] A first set of textile samples (2" x 2" squares of red satin textile) were soiled with polar stains by pipetting droplets of an 8 wt % aqueous sodium chloride solution on each of the textile samples of the set. A second set of textile samples were soiled with nonpolar stains by pipetting droplets of fresh motor oil (Quaker State SAE 10W-30) on each of the textile samples of the set. Each of the dry cleaning compositions was then placed in a 4 ounce bottle. Each of the soiled textile samples was contacted with a respective one of the cleaning compositions by immersing the soiled textile sample in 50 g of one of the cleaning compositions. The textile samples and cleaning compositions were agitated by gently shaking each of the bottles. Following agitation, each of the textile samples was removed from the cleaning composition, allowed to drain, blotted and then heated at ~50°C to dry the samples. The appearance of each of the dried textile samples was then evaluated by visual inspection and rated on the following scale (an average of three readings is reported):

Rating	5 = complete removal of stain
	4 = slight stain remaining
	3 = moderate stain removal
	2 = slight stain removal
	1 = no stain removal

[0036] The amounts of linear, branched and cyclic siloxanes, polyether siloxane and water used in each of Exam-

TABLE II (continued)

EX #	MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
30	47	Salt	B/E	1.25/1.25	0.5	3.7

TABLE III

EX #	MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
31	49.5	Oil	--	--	--	5
32	49.5	Oil	A	0.5	--	5
33	49	Oil	A	0.5	0.5	4.3
34	49.5	Oil	F	0.5	--	4.3
35	49	Oil	F	0.5	0.5	4.3
36	49.5	Oil	B	0.5	--	4.3
37	49	Oil	B	0.5	0.5	4.3
38	49.5	Oil	C	0.5	--	5
39	49	Oil	C	0.5	0.5	5
40	49.5	Oil	D	0.5	--	5
41	49	Oil	D	0.5	0.5	5
42	49.5	Oil	E	0.5	--	5
43	49	Oil	E	0.5	0.5	4.7
44	49.5	Oil	B/E	0.25/0.25	--	4.7
45	49	Oil	B/E	0.25/0.25	0.5	4.7

TABLE IV

EX #	MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
46	47.5	Oil	--	--	--	5
47	47.5	Oil	A	2.5	--	4.3
48	47	Oil	A	2.5	0.5	5
49	47.5	Oil	F	2.5	--	4.7
50	47	Oil	F	2.5	0.5	4.3
51	47.5	Oil	B	2.5	--	5
52	47	Oil	B	2.5	0.5	4.3
53	47.5	Oil	C	2.5	--	5
54	47	Oil	C	2.5	0.5	4
55	47.5	Oil	D	2.5	--	5

TABLE VI (continued)

EX #	D_5/MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
82	23.5/23.5	Salt	B	2.5	0.5	4.7
83	23.75/23.75	Salt	C	2.5	--	3.3
84	23.5/23.5	Salt	C	2.5	0.5	5
85	23.75/23.75	Salt	D	2.5	--	4.7
86	23.5/23.5	Salt	D	2.5	0.5	5
87	23.75/23.75	Salt	E	2.5	--	4
88	23.5/23.5	Salt	E	2.5	0.5	4
89	23.75/23.75	Salt	B/E	1.25/1.25	--	4.7
90	23.5/23.5	Salt	B/E	1.25/1.25	0.5	3.7

TABLE VII

EX #	D_5/MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
91	24.75/24.75	Oil	--	--	--	3
92	24.75/24.75	Oil	A	0.5	--	4.7
93	24.5/24.5	Oil	A	0.5	0.5	4.7
94	24.75/24.75	Oil	F	0.5	--	4.3
95	24.5/24.5	Oil	F	0.5	0.5	4.7
96	24.75/24.75	Oil	B	0.5	--	4.3
97	24.5/24.5	Oil	B	0.5	0.5	4.7
98	24.75/24.75	Oil	C	0.5	--	4.7
99	24.5/24.5	Oil	C	0.5	0.5	4
100	24.75/24.75	Oil	D	0.5	--	5
101	24.5/24.5	Oil	D	0.5	0.5	5
102	24.75/24.75	Oil	E	0.5	--	5
103	24.5/24.5	Oil	E	0.5	0.5	4.7
104	24.75/24.75	Oil	B/E	0.25/0.25	--	4.3
105	24.5/24.5	Oil	B/E	0.25/0.25	0.5	4.3

TABLE VIII

EX #	D_5/MD_2M, Amount (g)	Stain	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
106	24.75/24.75	Oil	--	--	--	5
107	23.75/23.75	Oil	A	2.5	--	4.7

TABLE X

EX #	MD_2M, Amount (g)	Stain(20%)	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
131	49.5	Salt	--	--	--	3
132	49.5	Salt	E	0.5	--	2.7
133	49	Salt	E	0.5	0.5	3
134	49.5	Salt	C	0.5	--	4
135	49	Salt	C	0.5	0.5	4.3
136	49	Oil	-	-	--	5
137	49.5	Oil	E	0.5	--	5
138	49	Oil	E	0.5	0.5	5
139	49.5	Oil	C	0.5	--	5
140	49	Oil	C	0.5	0.5	5
141	49	Salt	E	0.5	1.5	4.7

TABLE XI

EX #	MD_2M, Amount (g)	Stain(7%)	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
142	49.5	Salt	--	--	--	3
143	49.5	Salt	E	0.5	--	3
144	49	Salt	E	0.5	0.5	5
145	49.5	Salt	C	0.5	--	4.3
146	49	Salt	C	0.5	0.5	4

TABLE XII

EX #	D_5/MD_2M, Amount (g)	Stain(20%)	Polyether Siloxane	Polyether Siloxane, Amount (g)	H_2O, Amount (g)	Cleaning
147	24.75/24.75	Salt	--	--	--	3.3
148	24.75/24.75	Salt	E	0.5	--	3.3
149	24.5/24.5	Salt	E	0.5	0.5	3
150	24.75/24.75	Salt	C	0.5	--	4
151	24.5/24.5	Salt	C	0.5	0.5	4.7
152	24.75/24.75	Oil	-	-	--	5
153	24.75/24.75	Oil	E	0.5	--	5
154	24.5/24.5	Oil	E	0.5	0.5	5

the cleaning composition.

4. The method of claim 3, wherein, subsequent to contacting the article with the cleaning composition, the cleaning composition is separated from the article by one or more of draining and centrifugation.

5. The method of claim 4, wherein, subsequent to separation of cleaning composition from the article, the article is heated to a temperature of from 15 °C to 120 °C

6. The method of claim 4 or claim 5, wherein, subsequent to separation of cleaning composition from the article, the article is subjected to reduced pressure.

7. The method of claim 1, wherein the cleaning composition further comprises a surfactant and/or a cyclic siloxane.

8. A cleaning composition, comprising a linear or branched volatile siloxane and a surfactant.

9. The cleaning composition of claim 8, wherein the linear or branched volatile siloxane comprises one or more compounds of the structural formula:

$$M_{2+y+2z}D_xT_yQ_z$$

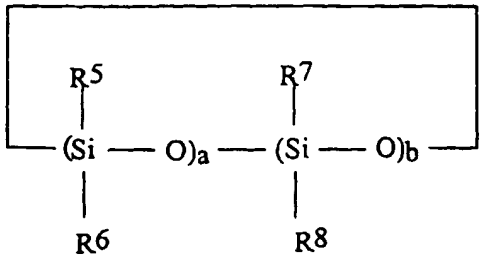
wherein:

M is $R^1{}_3SiO_{1/2}$;
D is $R^2{}_2SiO_{2/2}$;
T is $R^3SiO_{3/2}$;
and Q is $SiO_{4/2}$
R^1, R^2 and R^3 are each independently a monovalent hydrocarbon radical; and
x and y are each integers, wherein $0 \le x \le 10$ and $0 \le y \le 10$ and $0 \le z \le 10$.

10. The composition of claim 9, wherein the surfactant exhibits an HLB value of from 3 to 14.

11. A cleaning composition, comprising a linear or branched volatile siloxane and a cyclic siloxane.

12. The cleaning composition of claim 11, wherein the cyclic siloxane comprises one or more compounds of the structural formula:



wherein:

R^5, R^6, R^7 and R^8 are each independently a monovalent hydrocarbon group; and
a and b are each integers wherein $0 \le a \le 10$ and $0 \le b \le 10$, provided that $3 \le (a + b) \le 10$.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 2438

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